REMARKS

As of the filing of the present Office Action, claims 1-11, 13-24 and 38-49 were pending in the above-identified US Patent Application.

In the Office Action, the Examiner withdrew all previous rejections of the claims, but then rejected all of the pending claims on new grounds under 35 USC §103. In response, Applicants have amended the claims as set forth above. More particularly:

Independent claim 1 has been amended to recite that the porous silicon (55,212) has interior and exterior surfaces (inherent), to eliminate "current sources" from the list of releasing means, to specify that a releasing means in the form of a light source (14) emits sufficient photonic energy at a wavelength at which the porous silicon (55,212) is sufficiently transparent and the photonic energy is sufficiently absorbed by the chemisorbed hydrogen atoms (52) to promote the liberation of chemisorbed hydrogen atoms (52) from the dangling bond sites ([0038] and [0058]), and to specify that a releasing means in the form of a voltage source (18) that creates an electric field sufficient to affect the silicon activation energies and promote the liberation of chemisorbed hydrogen atoms (52) from the dangling bond sites ([0040] and [0057]).

Independent claim 8 has been amended to recite that the silicon

columns (202) have dendritic spikes (230) or non-conformal growth (226) formed by an additive silicon deposition process ([0073]-[0074]).

Dependent claim 13 has been amended to address a clerical error that formed the basis for the objection to claim 13.

Dependent claims 16 and 38 have been amended to eliminate "current sources" from the list of releasing/liberating means.

Dependent claim 41 has been amended to recite the "feature sizes" as present in the interior of the porous silicon (55,212).

In view of the amendments to claims 1 and 16, dependent claims 45 and 48 have been amended to recite a heat source (16) as an additional releasing/liberating means for promoting the liberation of the chemisorbed hydrogen atoms. The use of the term "heat" is based on paragraph [0039] of the specification.

Finally, claims 18, 38, and 44-49 have been amended to use the term "promote" consistent with claims 1 and 16.

Applicants believe that the above amendments do not present new matter. Favorable reconsideration and allowance of remaining claims 1-11, 13-24, 38-49 are respectfully requested in view of the above amendments and the following remarks.

Objection to Claim 13

As noted above, dependent claim 13 has been amended to correct a clerical that is believed to overcome this objection, and therefore Applicants respectfully request withdrawal of the objection.

Rejections under 35 USC §112, first and second paragraph

Dependent claim 41 was rejected as failing to comply with the written description requirement and indefiniteness. The §112 ¶1 rejection was on the basis that the "feature sizes" disclosed in [0071] refers to silicon columns (202) and not interior surfaces of porous silicon (55,212), and the §112 ¶2 rejection was on the basis that it is unclear as to what "features" of an interior surface are being referred to as having "feature sizes" of about one nanometer.

Claim 41 has been amended to recite the "feature sizes" of the porous silicon (55,212) as "structures" within the interior of the porous silicon (55,212), for example, see the walls that separate the pores in the silicon (212) in FIGS. 4 and 5. It is noted that paragraph [0071] discloses porous silicon (55,212) formed from comminuted silicon, and not silicon columns (202) as stated in the Office Action.

In view of the amendment, Applicants respectfully believe that the §112

rejections of claim 41 are overcome, and therefore respectfully request their withdrawal.

§103 Rejections of Independent Claim 1 and Its Dependent Claims

Independent claim 1 and its dependent claims 3-6, 19-24, 38, 39 and 42-45 were rejected as unpatentable over U.S. Published Patent Application No. 2004/0016769 to Redmond in view of U.S. Patent No. 4,265,720 to Winstel and U.S. Pat. No. 5,882,496 to Northrup et al. (Northrup) in further view of U.S. Patent No. 5,882,623 to Zaluska et al. (Zaluska). Dependent claim 2 was rejected in further view of U.S. Published Patent Application No. 2004/0048466 to Gore et al. (Gore), dependent claim 7 was rejected in further view of U.S. Patent No. 5,196,377 to Wagner et al. (Wagner), dependent claims 17 and 18 were rejected in further view of U.S. Patent No. 6,540,377 to Ota et al. (Ota), and dependent claim 46 was rejected in further view of U.S. Patent No. 6,964,890 to Yamazaki et al. (Yamazaki).[1]

Applicants respectfully request reconsideration of the rejections of

[1] Claim 41, which depends from claim 1, was neither subjected to a prior art rejection nor deemed to recite allowable subject matter. Applicants' remarks are made on the presumption that claim 41 was intended to be rejected in view of the prior art applied to its parent claim 1.

independent claim 1 and its dependent claims 2-7, 17-24, 38, 39, 41-46 in view of the amendments presented above as well as the following comments.

As now amended, independent claim 1 requires a releasing means as including one or more light sources (14) and/or voltage sources (18). The light sources (14) are specified as emitting sufficient photonic energy at a wavelength at which silicon is sufficiently transparent and the photonic energy is sufficiently absorbed by the chemisorbed hydrogen atoms (52) to promote the liberation of chemisorbed hydrogen atoms (52) from the dangling bond sites of the porous silicon (55,212). The voltage sources (18) are specified as creating an electric field sufficient to affect the silicon activation energies and promote the liberation of chemisorbed hydrogen atoms (52) from dangling bond sites of the porous silicon (55,212).

Page 8 of the Office Action uses the term “non-thermal”, which appears to be borrowed from Zaluska. While Zaluska asserts the use of “non-thermal” energy sources for hydrogen desorption from a metal hydride, all of the methods disclosed by Zaluska serve to heat the metal hydride. Zaluska narrowly defines the term “non-thermal energy source” as follows:

> As a matter of fact, this expression [“non-thermal energy source”] is exclusively used to exclude "conventional" heat sources such as gas or oil burners where heat is produced and transferred

mainly by convection to the metal hydrides.

Zaluska then goes on to teach that such "non-thermal energy sources" produce "intrinsic heating" or "introduc[e] and accumulat[e] energy" (column 2, lines 32-45), the former and latter of which include, respectively, the use of "electric energy where heat is generated by Joule effect" and radiation energy in the form of "high intensity light sources, ion sources, lasers and the like." Because the theory of heat states that temperature is the mechanical vibratory motion of atoms or molecules relative to one another, any means that increases atomic or molecular vibration is, in fact, a thermal means. Every example and all of the methods described in Zaluska result in heating of a metal hydride for the purpose of desorbing hydrogen, and therefore all are thermal methods, regardless of the name given by Zaluska. Zaluska's electric energy method ("by Joule effect") is clearly a heating method. Zaluska's examples of radiation energy ("high intensity light sources, ion sources, lasers and the like") are also clearly intended to heat a metal hydride.

In contrast, Applicants independent claim 1 recites releasing means for hydrogen desorption that do not involve heating - namely, photon release and electric fields. When a single photon releases a single hydrogen atom from a Si-H bond, there is no heat applied to the silicon and the released hydrogen

atom will have negligible thermal energy. In semiconductor materials such as silicon, an applied electric field shifts the Fermi level of the free carriers, again without increasing temperature. Therefore, Applicants' claimed releasing means is different than and not suggested by the thermal/heating methods taught by Zaluska.

Page 8 of the Office Action states that it is "inherent" that "high intensity light source would pass photonic energy through the hydrogen storage media." However, this is simply not true as evidenced by the graph attached as Exhibit A. Silicon is opaque to visible light and to UV light, regardless of the intensity of the light source.

In view of the above, Applicants respectfully believe that the releasing means now specified in independent claim 1 (as well as its dependent claims 17, 18, 38, 44 and 46) are different and contrary to the releasing means and methods disclosed by Zaluska. Because Zaluska was the only reference cited for teaching hydrogen desorption using radiation produced by high intensity light sources, Applicants respectfully believe that the rejection of claim 1 is overcome and respectfully request its withdrawal.

Regarding claim 2, page 9 of the Office Action cites Gore for a textured silicon surface that may include "spikes." However, Gore's spikes are not

equivalent to Applicants' claimed "dendritic spike" (230) or "non-conformal growth" (226), and are not formed by an additive process. Instead, Gore's process is a subtractive process (etching). The word "dendrite" comes from the Greek word for tree, and refers to a branching figure. Gore's structure has no branching, and therefore is not dendritic. Gore's process is subtractive, and therefore is not additive or otherwise entail a "non-conformal growth." Because Gore was the only reference cited for teaching the limitations of claim 2, Applicants respectfully believe that the rejection of claim 2 was improper and respectfully request its withdrawal.

Regarding claims 17 and 18 and Ota, Applicants are not claiming to be the first to use "a light source that is a red light emitting diode which is a light source that inherently emits photon energy at a wavelength of about 660 nanometer[s]" (Page 18 of the Office Action). However, Applicants are claiming to be the first to employ electromagnetic radiation at this wavelength to desorb hydrogen bonded to interior surfaces of porous silicon (55,212) - a capability not disclosed by Ota or any other prior art reference of record. Because Ota was the only reference cited for teaching the limitations of claims 17 and 18, Applicants respectfully believe that the rejection of claims 17 and 18 was improper and respectfully request its withdrawal.

Also regarding claims 17 and 18, page 18 of the Office Action asserts that "[t]he wavelength of the light source is recognized in the art as a results effective variable for causing hydrogen atoms to be liberated from a silicon material." However, Ota merely teaches the existence of light-emitting diodes (LEDs) that emit light in the visible light spectrum that includes red, green and blue. No evidence is provided to substantiate the assertion that "[t]he wavelength of the light source is recognized in the art as a results effective variable for causing hydrogen atoms to be liberated from a silicon material," and Applicants respectfully believe that the rejection of claims 17 and 18 cannot be maintained without such evidence.

Regarding claim 46, Yamazaki was cited for teachings that are clearly erroneous. *The Handbook of Inorganic Chemicals*, P. Patnaik, McGraw-Hill (2003), provides the following:

Silicon Bond	ENERGY (eV)	Carbon Bond	ENERGY (eV)
Si-Si	1.84	C-C	2.54
Si-H	3.25	C-H	3.78
Si-O	3.87	C-0	3.03

Yamazaki alleges that the Si-H bond is "generally weak." However, the table above establishes that the Si-H bond is greater than the Si-Si bond by 77%. In other words, the Si-H bond is stronger than the bond that holds the silicon

matrix together. Consequently, the Si-H bond is clearly not weak and desorption of hydrogen from dangling bonds of porous silicon (55,212) is not trivial, as one might erroneously conclude from Yamazaki's statement.

The Office Action cites another erroneous statement made by Yamazaki that suggests a "few tens of degrees" can release hydrogen from silicon. The equation relating energy to temperature is

$$U_{thermal} = 3/2\ K\ t$$

Using 30°C for T (representative of a "few tens of degrees"), one arrives at 0.0039 eV (electron Volt) for the thermal energy ($U_{thermal}$). Comparing this to the bond energies in the table above, it is clear that Yamazaki's suggestion that heating a "few tens of degrees" can release hydrogen from silicon is wrong by factor of about 800.

In view of the above, Applicants respectfully believe that Yamazaki cannot be relied on to teach anything regarding hydrogen desorption from silicon, at least as it pertains to hydrogen storage as taught by Applicants and other prior art references of record.

In any event, Yamazaki clearly teaches the desorption of hydrogen by applying an electric voltage or current to heat silicon (column 2, lines 43-46), which again is not the releasing/liberating means recited in independent claim

1 and its dependent claims 17, 18, 38, 44 and 46. Because Yamazaki was the only reference cited for teaching the limitations of claim 46, Applicants respectfully believe that the rejection of claim 46 was improper and respectfully request its withdrawal.

For all of the above reasons, Applicants respectfully request withdrawal of the rejections of independent claim 1 and its dependent claims.

§103 Rejections of Independent Claim 8 and Its Dependent Claims

Independent claim 8 and its dependent claim 13 were rejected as unpatentable over Winstel in view of U.S. Patent No. 7,135,057 to Kornilovich, in further view of Northrup and as evidenced by Woo, claims 9-11 were rejected as unpatentable over Winstel, Kornilovich, Northrup and Woo in further view of U.S. Published Patent Application No. 2002/0158284 to Kim, claims 14 was rejected as unpatentable over Winstel, Kornilovich, Northrup and Kim in further view of U.S. Patent No. 6,040,230 to Anthony et al. (Anthony), claims 15 and 40 were rejected as unpatentable over Winstel, Kornilovich and Northrup in further view of Redmond, claim 16 was rejected as unpatentable over Winstel, Kornilovich, Northrup and Redmond in further view of Zaluska, claims 47 and 48 were rejected as unpatentable over Winstel,

Kornilovich and Northrup in further view of Zaluska, and claim 49 was rejected as unpatentable over Winstel, Kornilovich and Northrup in further view of Yamazaki.

Applicants respectfully request reconsideration of the rejections of independent claim 8 and its dependent claims 9-11, 13-16, 40, and 47-49 in view of the amendments presented above as well as the following comments.

As now amended, independent claim 8 requires silicon columns (202) that have dendritic spikes (230) or non-conformal growth (226) formed by an additive silicon deposition process. None of the prior art of record disclose or suggest a hydrogen storage member comprising a porous mesh (59) of crystalline silicon columns (202) having diameters of about 1 nanometer and Applicants' additional claimed feature. Because Gore was the only reference cited for teaching the limitations inserted into claim 8, Applicants respectfully believe that the rejections of claim 8 and its dependent claims are overcome and respectfully request their withdrawal.

Under the rejection of claim 8 and its dependent claim 13, the Office Action stated

> it would have been obvious to one of ordinary skill in the art at the time the invention was made to modify Winstel system for storing and retrieving hydrogen to include a hydrogen storage member

> comprising a porous mesh of silicon columns, wherein the silicon columns are extruded through at least one aperture that is an integral multiple of the lattice spacing of silicon such that the silicon columns have a minimum energy configuration suitable for forming a crystal in order to improve the storage efficiency of the hydrogen storage medium and to allow fast diffusion of gas molecules such as hydrogen gas.

The limitation of "silicon columns have a minimum energy configuration" is recited in claim 11, not claim 8 or 13. In any event, the Office Action does not site any of the references as teaching "silicon columns have a minimum energy configuration," or how this characteristic is relevant to hydrogen absorption/desorption. Such teachings are only found in Applicants' specification, which cannot be used as hindsight to reconstruct Applicants' invention from the prior art. Therefore, Applicants respectfully believe that this ground for rejecting the claims, and specifically the rejection of claim 11, is improper, and respectfully request its withdrawal.

Regarding claim 14, Anthony was cited for etching polysilicon structures "with oxygen in order to roughen the surface." However, those skilled in the art would not look to such teachings in order to modify the teachings of Kornilovich, Northrup or Kim, since the oxygen etch would tie up the dangling bonds required to desorb hydrogen by forming oxygen-silicon bonds that are stronger than hydrogen-silicon bonds (see *The Handbook of Inorganic*

Chemicals, supra), destroying the hydrogen carrying capability of silicon. Therefore, Anthony cannot be used to modify the prior art of record to arrive at Applicants' invention recited in claim 14, and Applicants respectfully request withdrawal of this rejection.

Finally, Zaluska and Yamazaki do not teach or suggest the releasing/liberating means recited in claims 16, 47 and 49 for the reasons discussed above under the rejections of independent claim 1 and its dependent claims. In particular, both Zaluska and Yamazaki disclose desorbing hydrogen by heating the absorption media, which is contrary to the two techniques now recited in claims 16, 47 and 49. Because Zaluska and Yamazaki were the only references cited for teaching the limitations of claims 16, 47 and 49, Applicants respectfully believe that the rejections of these claims were improper and respectfully request their withdrawal.

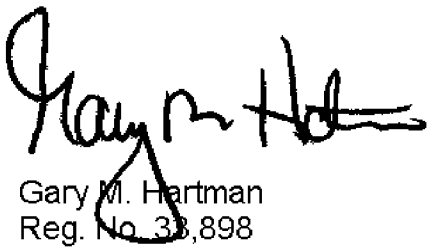
For all of the above reasons, Applicants respectfully request withdrawal of the §103 rejections of independent claim 8 and its dependent claims.

Closing

In view of the above, Applicants believe that the claims define patentable novelty over all the references, alone or in combination, of record. It is therefore respectfully requested that this patent application be given favorable reconsideration.

Should the Examiner have any questions with respect to any matter now of record, Applicants' representative may be reached at (219) 462-4999.

Respectfully submitted,



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Attachments: Exhibit A

Exhibit A

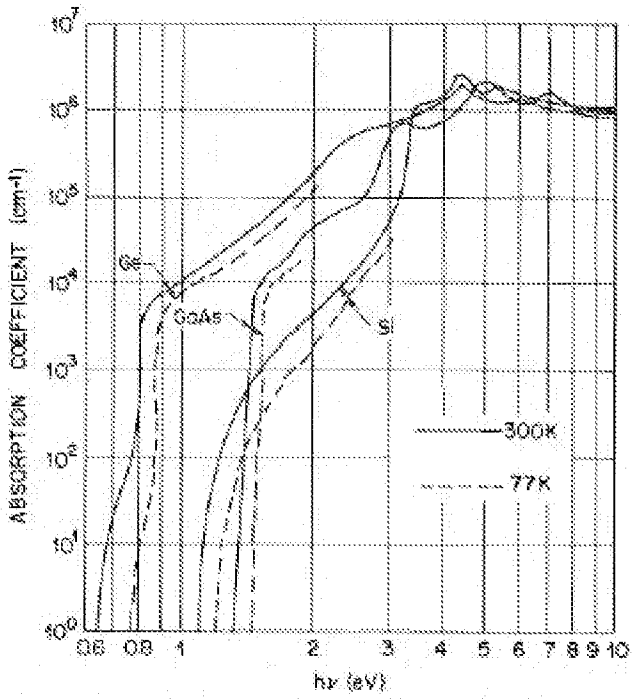

Fig. 27 Measured absorption coefficients near and above the fundamental absorption edge for pure Ge, Si, and GaAs. (After Dash and Newman, Ref. 51; Philipp and Taft, Ref. 52; Hill, Ref. 53; Casey, Sell, and Wecht, Ref. 54.)